FRD Activities Report
February 2000

Research Programs

Shoaling Waves Experiment (SHOWEX)

Preliminary analysis has begun on data acquired by the LongEZ during the Shoaling Waves Experiment. On 20 November 1999, the LongEZ flew repeated flux legs over the western edge of the Gulf Stream at an altitude of 10 m to help understand surface forcing on the atmosphere. Figure 1 is an example of a 30-km flux leg. In this instance, this leg was flown in about 9 min as the LongEZ headed east. Three distinct atmospheric flow regimes can be seen in this figure: Stable, transitional, and unstable.

The stable regime is marked with an absence of turbulent activity. The mean wind speed is 1.3 m s^{-1} from the west. On average, the atmosphere is 3.9° C warmer than the underlying sea surface. The variances of the alongwind (F^2_u), crosswind (F^2_v), and vertical wind velocity (F^2_w), air temperature (F^2_T), and humidity (F^2_q) are all minimal (Table 1). The sensible (H_S) and latent heat (H_E) fluxes are essentially zero. Other turbulent statistics include wind stress (J), friction velocity (u_t), temperature scale (T_t), humidity scale (q_t), drag coefficient (C_D), Monin-Obhukhov length (L), and surface layer stability (. = z / L). All of these values are indicative of a stable marine atmospheric boundary layer (MABL).

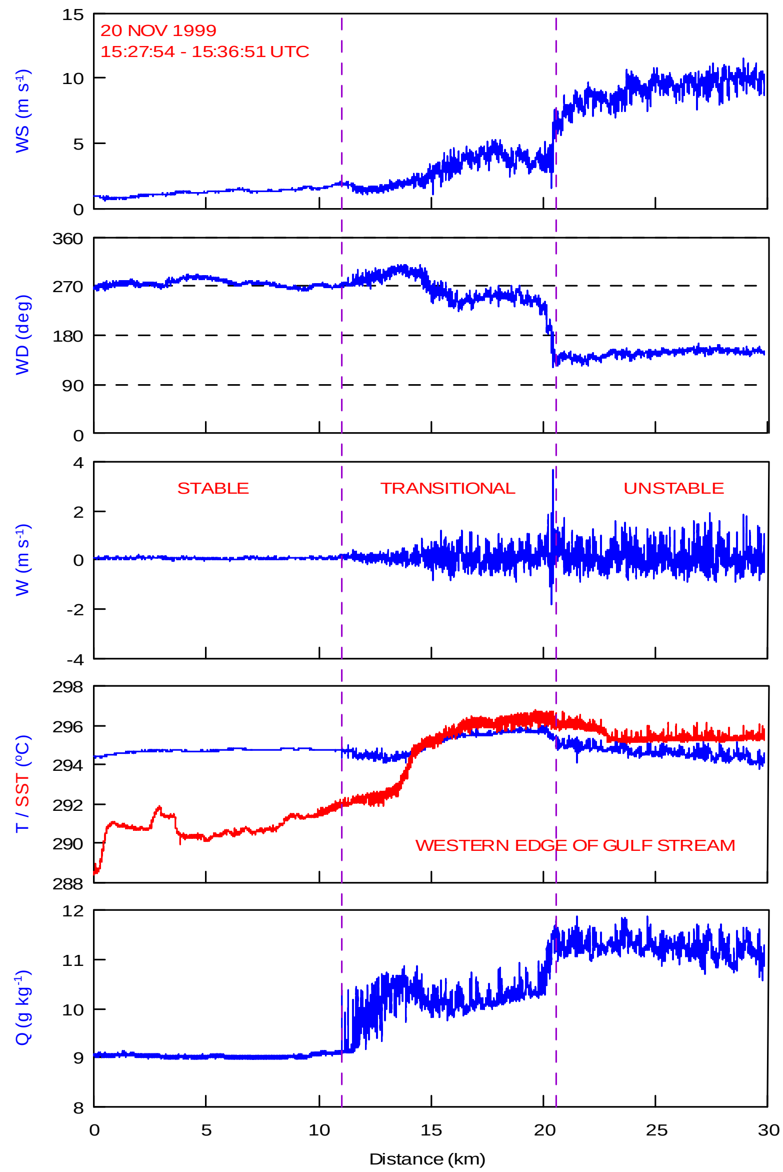

Figure 1. Time series acquired by the LongEZ during a 30-km flux leg at an altitude of 10 m near the western edge of the Gulf Stream. From the top: Wind speed, wind direction, vertical wind speed, air and sea surface temperature, and specific humidity.

The start of the transitional MABL is quite dramatic. The wind speed increases from 2 to 6 m s^{-1} over a distance of 10 km while the wind direction backs from westerly to southeasterly. As the LongEZ begins crossing the western edge of the Gulf Stream, the sea surface temperature increases about 4 °C over a distance of 10 km. The air-sea temperature difference also switches signs in this portion of the MABL. Large increases are observed in all of the variables. However, these statistics are somewhat inflated by the nonhomogeneous nature of the MABL. When applying eddy correlation techniques to a nonhomogeneous time series with step-like changes, artificial increases of the variance are injected. We note that while the sensible heat flux is extremely small, a significant increase in the latent heat flux to 73 W m^{-2} is observed. The wind stress increases by two orders of magnitude while the friction velocity is about ten times that found in the stable MABL. The drag coefficient also increases dramatically, while the Monin-Obukhov length switches signs and has increased by one order of magnitude.

We note a leveling off of sea surface temperature in the unstable MABL where the air temperature is now about 1° C cooler that underlying ocean water. Average wind speed is 9.0 m s^{-1} from the southeast. While the air temperature has not changed dramatically over the length of the entire leg, the specific humidity has risen from 9.0 g kg^{-1} in the stable MABL to 11.3 g kg^{-1} in the unstable MABL. The sensible and latent heat fluxes have increased to 46 and 108 W m^{-2}, respectively. Values of J and u_t remain nearly the same as that found in the transitional MABL; however, significant increases in T_t and q_t can be seen. Values for L and . are typical values for an unstable MABL. (Jerry.Crescenti@noaa.gov, Jeff French, and Tim Crawford)

Table 1. Turbulent statistics from LongEZ flux leg.

	Stable	Transitional	Unstable
F^2_u (m^2 s^{-2})	0.01	0.80	0.38
F^2_v (m^2 s^{-2})	0.02	0.59	0.41
F^2_w (m^2 s^{-2})	0.00	0.11	0.16
F^2_T (°C^2)	0.00	0.05	0.03
F^2_q (g^2 kg^{-2})	0.00	0.11	0.03
H_S (W m^{-2})	0	4	46
H_E (W m^{-2})	1	73	108
J (N m^{-2})	0.001	0.080	0.084
u_t (m s^{-1})	0.033	0.259	0.267
T_t (°C)	0.008	-0.012	-0.145
q_t (g kg^{-1})	-0.006	-0.096	-0.139
C_D	0.00066	0.00923	0.00087
L	11	-412	-38
.	0.92	-0.02	-0.27

Hurricane balloons

Testing on the Hurricane Balloon software continues. All known bugs appear to be fixed and the test system has run for 12 days without an error. (Roger.Carter@noaa.gov, Randy Johnson)

High Speed Temperature Probe

Several different probe materials have been tested for a 50 Hz response and a near $1x10^{-3}$ ° C resolution. We have been successful at getting the temperature resolution and frequency response with $5x10^{-4}$ inch diameter, 200 ohm tungsten wire. However, when placed inside the probe and subjected to turbulence and other vibrations, noise is induced in the temperature signal due to flexing of the tungsten wire. The mechanically induced noise ranges around 2 to $3x10^{-2}$ ° C while it is being vibrated and returns to under $1x10^{-3}$ ° C without vibration. We have isolated the vibration to the tungsten filament to be sure that it is not a loose connection or some other component causing the problem. By simulating very low vibration to the filament, we are able to watch the phase of the output temperature maintain phase with the vibration. There does not seem to be any practical resolution to this problem.

We have previously done some work with thermocouple wire but abandon this approach because of the low output signal levels. Although the thermocouple has two orders of magnitude less output signal per °C, we do not need to worry about self heating due to excitation current or changes in probe resistance caused by mechanical flexing. We are presently working with some fine gage (.0005 inch) thermocouple wire feeding into an ultra low noise DC amplifier. We are continuing to experiment with this and are finding $3x10^{-3}$ ° C random electrical noise and are working to reduce this noise. So far, we have not seen substantial mechanical noise using the thermocouple. We are now working on a design to chop the low level DC signal into a high frequency AC signal, amplify the AC signal and then run it through a high pass filter to remove low frequency amplifier noise. (Randy.Johnson@noaa.gov and Tim Crawford)

<u>Cooperative Research with INEEL</u>

Tornados Strike Southeastern Idaho

The afternoon of Valentine's Day, 2000, proved to be one for the record books, at least in southeastern Idaho. What began as a warm, moist spring day, ended in darkness with major power outages and wind damage caused by severe storms. A strong cold front pushed through the area spawning five tornados: two F0 and three F1 Fujita Scale tornados. The INEEL mesonet provided valuable information on the position of the frontal passage to both NWS and FRD forecasters. During the followup, the mesonet provided clues for personnel in charge of providing damage assessment reports.

As a result of the storm, nine of the 33 mesonet stations recorded new wind gust maximums (see Table 2). The storm registered a maximum gust of 43 m s^{-2} (96 mph) and Minidoka, at nearly one-half of the stations recorded gusts above 33 m s^{-2} (70 mph), as illustrated in Figure 2. For 12 other stations, the wind gusts were among the top ten strongest gusts ever recorded for the data period of record, as listed in Table 3. (Kirk.Clawson@noaa.gov and Neil Hukari)

Table 2. INEEL mesonet stations with new record peak wind gusts from the February 14, 2000 storm.

Station Name	Peak Speed (mph)	Time (MST)	Old Record	Data Period
Atomic City	74.1	1555	60.2 mph on 11/26/99	Sep 1999 - Feb 2000
Big Southern Butte	92.9	1520	90.0 mph on 07/09/95	Apr 1993 - Feb 2000
Blackfoot	85.7	1630	78.0 mph on 04/23/94	Apr 1993 - Feb 2000
Fort Hall	77.3	1600	69.6 mph on 06/17/97	Mar 1997 - Feb 2000
Idaho Falls	69.4	1620	62.8 mph on 09/25/99	Apr 1993 - Feb 2000
Lost River Rest Area	73.5	1530	63.6 mph on 09/18/99	Nov 1997 - Feb 2000
Minedoka	96.3	1500	72.7 mph on 07/09/95	Apr 1993 - Feb 2000
Naval Reactor Facility	77.4	1550	72.7 mph on 07/10/95	Apr 1993 - Feb 2000
Rover	87.7	1605	78.6 mph on 06/16/96	Apr 1993 - Feb 2000

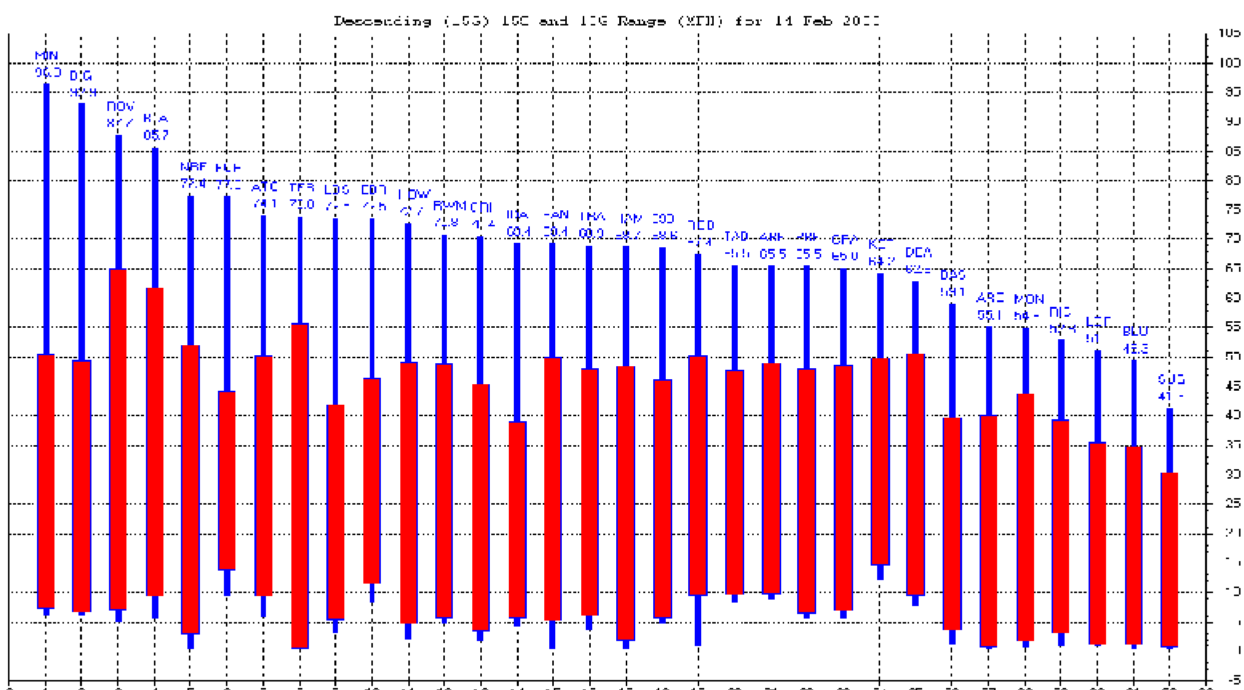

Figure 2. Peak wind gusts and ranges of 5-min wind speeds (mph) for the INEEL mesonet on February 14, 2000, arranged in descending order.

Table 3. INEEL mesonet stations with peak wind gusts in the top 10 events from the February 14, 2000 storm.

Station Name	Peak Speed (mph)	Time (MST)	Current Record	Data Period
CFA Building 690	68.6	1535	75.8 MPH on 07/09/95	Apr 1993 - Feb 2000
Aberdeen	65.5	1610	69.7 MPH on 09/25/99	Apr 1993 - Feb 2000
EBR-2	73.5	1600	73.8 MPH on 05/08/98	Apr 1993 - Feb 2000
Grid-3	70.4	1550	81.6 MPH on 07/31/94	Apr 1993 - Feb 2000
Howe	72.7	2135	79.8 MPH on 11/01/94	Apr 1993 - Feb 2000
Power Burst Facility	65.6	1555	77.1 MPH on 07/10/95	Apr 1993 - Feb 2000
Roberts	67.4	1620	69.1 MPH on 04/23/94	Apr 1993 - Feb 2000
RWMC	70.8	1545	78.0 MPH on 07/10/95	Apr 1993 - Feb 2000
Sand Dunes	69.4	1555	79.8 MPH on 07/09/95	Apr 1993 - Feb 2000
Taber	65.5	2250	69.5 MPH on 12/04/95	Apr 1993 - Feb 2000
Terreton	73.8	1610	80.7 MPH on 07/10/95	Apr 1993 - Feb 2000
Test Reactor Area	68.9	1550	79.3 MPH on 07/09/95	Apr 1993 - Feb 2000

Emergency Operations Center (EOC) Support

During the afternoon and evening of Feb 14, 2000, a series of strong storms moved through southeastern Idaho causing extensive wind damage and widespread power outages. The entire INEEL computer network went down as a result of the power outages. However, the dedicated link from the FRD office to the EOC remained operational because of backup generators at the FRD office, the EOC, and some key INEEL facilities. Emergency responders working at the EOC were able to access timely weather information throughout the EOC activation.

The EMWIN system at the EOC received a new laptop computer in February. Since the EMWIN system is left running 24 hours/day, the laptop disk drive has a difficult time standing up to continuous usage. If this problem occurs again we will have to resolve the situation with different equipment. (Roger.Carter@noaa.gov)

Portable Meteorological Monitoring Station

Work has commenced on building a portable meteorological monitoring station for and INEEL incident command bus. The station will be deployed by the bus for monitoring local meteorological conditions. A digital readout will be displayed in the bus and the data will be ingested into the INEELViz display (see http://www.noaa.inel.gov/frd/Capabilities/ inelviz.html). Thus, the data can be displayed on every INEELViz client. (Kirk.Clawson@noaa.gov and staff)

We have recently purchased a small, portable, all-in-one met station that is manufactured by Climatronics. The purpose of this station is to allow us or others to set up a station during emergencies in little time with no expertise required by the person setting up the station. The station includes wind speed, wind direction, temperature and relative humidity. A small electronic compass is built into the 2D sonic wind speed and direction transducer to allow automatic direction orientation of the unit regardless of its physical orientation.

Over the past two weeks we have placed the unit in very close proximity to our Aberdeen, Idaho station to compare long term signal output with the conventional meteorological sensors at this station. Most of the time the outputs match very well. However, we have experienced times when the wind speed shows long term averages (tens of minutes) that are tens of meters per second too high. We will be working with Climatronics to determine the source of this problem. (Randy.Johnson@noaa.gov)

Emergency Response Training

The power outage associated with the Valentine's Day storm inadvertently tested the readiness of some of the INEEL emergency preparedness procedures. The storm knocked out internet access to the FRD facility, leaving many facilities with non-functioning INEELViz clients. FRD had previously planned for such an event by providing direct phone access to meteorological data. A training session was provide following the storm to remind emergency responders of this backup plan. (Kirk.Clawson@noaa.gov and Roger Carter)

Sagebrush Steppe Year-round Flux Monitoring Station

The sagebrush steppe ecosystem flux station at the INEEL continues to collect data. That system, together with a Bowen-Ratio system installed by USDA Agriculture Research Service scientists continues to generate interest, particularly among range scientists. A modification to the flux collection software was completed to overcome a minor Y2K bug. (Kirk.Clawson@noaa.gov)

Other Activities

New Web Site for the AMS Measurements Committee

The American Meteorological Society's (AMS) Committee on Measurements has recently developed a web page to describe its activities (http://measure.noaa.inel.gov). Included are the Committee's mission statement, a list of its current members, the awards that the Committee is responsible for, annual reports to the AMS, detailed information about the upcoming 11th Symposium for Meteorological Observations and Instrumentation (SMOI), and its upcoming short course on the basics of meteorological instruments and observation techniques. (Jerry.Crescenti@noaa.gov)

Proposals

An Aerosol and Radiation Study Using a Small Research Aircraft in ACE-Asia by Jeffrey R. French, Steven B. Brooks, and Timothy L. Crawford was submitted to NOAA Office of Global Programs for the ACE-Asia Spring 2001 IOP Initiative.

Autonomous Flux Vehicle (AFV) for Hurricane Research by Timothy L. Crawford, Steve Brooks, Gennaro H. Crescenti, and Jeffrey R. French planning letter was submitted to the Office of Naval Research (ONR) Coupled Boundary Layers / Air-Sea Transfer Research Initiative.

Development and Deployment of an Extreme Turbulence (ET) Probe for Hurricane and High Wind Research, by Timothy L. Crawford, Randall C. Johnson, Gennaro H. Crescenti, and Ronald J. Dobosy planning letter was submitted to the Office of Naval Research (ONR) Coupled Boundary Layers / Air-Sea Transfer Research Initiative.

Determination of the Spatial Variation of the Atmosphere and Ocean Wave Fields in Extremely Light Wind Regimes, by Gennaro H. Crescenti, Timothy L. Crawford, and Douglas Vandemark, planning letter was submitted to the Office of Naval Research (ONR) Coupled Boundary Layers / Air-Sea Transfer Research Initiative.

Human Impact on Hydrology and Atmospheric Processes in Semi-Arid Regions: Central Oregon Case Study, by Timothy L. Crawford, Gennaro H. Crescenti, and Jeffrey R. French, was submitted to Oregon State University as part of a National Science Foundation (NSF) research proposal.

MCA-C Air Sampling System Tests, March 2001, by Kirk L. Clawson, revised Statement of Work to release and track SF_6 at Dugway Proving Ground, UT. Submitted to U.S. Air Force, Patrick AFB, FL

Vertical Transport and Mixing Experiment CATS Tubes Sampling Cost Estimate, by Kirk L. Clawson. This estimate provides a plan to modify 40 of FRD's SF_6 samplers for perfluorocarbon sampling with CATS tubes in the VTMX study to be conducted in Salt Lake City, UT during October, 2000. Submitted to Pacific Northwest National Laboratory.

Proposals Reviewed

Development and Analysis of NEXRAD Hydrometeorological Algorithms, submitted to the NWS Hydrologic Research Laboratory by James Smith, Princeton University, reviewed by Jerry Crescenti.

Vertical Profile of Reflectivity and Beam Occulation Studies for Improved Radar-Rainfall Estimation, submitted to the NWS Hydrologic Research Laboratory by Witold Krajewski, University of Iowa, reviewed by Jerry Crescenti.

Papers

Sun, J., D. Vandemark, L. Mahrt, D. Vickers, T. L. Crawford, and C. Vogel, 2000: Momentum transfer over the coastal zone, *J. Geophy. Res.*, submitted.

Mourad, P. D., D Vandemark, T. L. Crawford, L. Mahrt, H. Stern, J. Sun, D. Thompson, and C. A. Vogel. 2000: Similarities and differences between the scales of wind forcing of the ocean surface measured in situ and the ocean's response to that forcing as imaged by synthetic aperture radar . Submitted to Geophysical Research Letters

Carter, R. G. and R. E. Keislar: Emergency Response Transport Forecasting Using Historical Wind Field Pattern Matching. *J. Appl. Meteor.*, **39**, 446-462.

Papers Reviewed

Finkelstein, P. L., and P. F. Sims, 2000: Sampling error in eddy correlation flux measurements. *J. Geophys. Res.*, ARL review by Jerry Crescenti.

Snyder, W. H., R. E. Lawson, Jr., M. S. Shipman, and J. Lu, 2000: Fluid modeling of atmospheric dispersion in the convective boundary layer. *Bound.-Layer Meteor.*, ARL review by Jerry Crescenti.

Tucker, D. F., and G. A. Marotz, 2000: Meteorological conditions for minimizing the spread of material in a combustion plume at the Sunflower Army Ammunition Plant in northeastern Kansas. *J. Appl. Meteor.*, reviewed by Jerry Crescenti.

Weil, J. C., W. H. Snyder, R. E. Lawson, and M. S. Shipman, 2000: Experiments on buoyant plume dispersion in a laboratory convection tank. *Bound.-Layer Meteor.*, ARL review by Jerry Crescenti.

Travel

Timothy L. Crawford attended workshop “Baroclinic Data Assimilation and Novel Observing Systems” in Gulfport, MS. February 21-24, 2000.

Visitors

Dr. Solomon Leung from Idaho State University visited FRD on February 11 to collaborate with Jerry Crescenti on boundary layer measurements made at the Boulder Atmospheric Observatory.

New Employee

We are pleased to announce that Dr. Richard M. Eckman, Meteorologist, has arrived at FRD to assume the mesoscale modeling responsibilities of retired meteorologist Jerry Sagendorf. Rick transferred to FRD from ATDD effective 2/28/00. Welcome aboard, Rick.

Retiring Employee

FRD continues to remain in a state of flux as another employee announces plans for retirement at the end of March. Dianne Hoover, Physical Scientist, has been employed full-time at FRD for the past 12 years. She has been a big asset in the preparation and conduct of FRD’s many tracer field experiments. We wish her luck in her new post-FRD life.